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Wood ash effect on the productive characteristics of Marandu grass in Cerrado soils

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The nutrient dynamics in soils are directly influenced by fertilizer application. Wood ash is an alternative fertilizer and soil corrective that provides enhanced fertility and increased crop production. This study aimed to evaluate the productive characteristics of Marandu grass and the functions of levels of plant ash in two Cerrado soils. The experiment was conducted in a greenhouse with a completely randomized design in a factorial 2 × 6 plot: two soils (oxisol and ultisol) and six doses of wood ash (0, 3, 6, 9, 12 and 15 g dm^{-3}) were tested in six replicates. The soil samples were collected in areas: the Cerrado, and wood ash from the ceramics industry was used as a fertilizer. Each experimental unit consisted of a plastic pot with up to 5 dm^{3} of soil and 5 plants of *Brachiaria brizantha* Marandu grass. Three cuts were made in the shoots at 30 days intervals to evaluate the productive characteristics, such as the number of leaves, number of tillers, and dry mass of shoot and root. The wood ash fertilizer influenced the production Marandu grass in the two Cerrado soils (ultisol and oxisol) and provided the maximum mass production of shoots (third cut), number of leaves (first and second cuts), number of tillers (first cut) and root mass (third cut) in typic oxisol.

Key words: *Brachiaria brizantha*, oxisol, ultisol.

INTRODUCTION

Wood ash is a solid material that remains after the complete burning of woody biomass (Coelho and Costa, 2012) and from a heated boiler (Nkana et al., 2002) for the purpose of energy production. As an alternative to landfilling, the application of wood ash to soil may become a promising method of waste removal (Pita, 2009) because of its large-scale production in large urban centers. The application of plant ash in agriculture is presented as an important opportunity for returning a portion of the nutrients removed by crops. The recycling of ash reduces the need for commercial fertilizers and contributes to the reduction soil of acidification and increase of the supply of calcium (Zimmerman and Frey, 2002).

The elemental composition of ash is determined mainly by the quality of the incinerated material (Augusto et al., 2008). Some studies have shown that gray woody biomass is an alkalizing soil corrective (Osaki and Darolt, 1991; Cabral et al., 2008; Ferreira et al., 2012) and an important source of nutrients, such as phosphorus,

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potassium, magnesium, and calcium (Nieminen et al., 2005; Lima et al., 2006; Sofiatti et al., 2007) .

The dynamics of nutrients in the soil are influenced by the incorporation of wood ash (Ferreira, 2012) because of its high alkalinity (Loué, 1978), which is shown by the neutralization of available aluminum (Al^{3+}) soil. Lima et al. (2009) suggested that wood ash has a greater capacity to increase the soil pH compared to cattle manure and can provide increased levels of phosphorus, potassium and magnesium (Obernberger et al., 1997).

Soils of the Cerrado biome are generally low in available nutrients, and wood ash can be an interesting alternative to improving fertility because it contributes directly to crop production. The pastures usually contain crops with tolerance to acid soils of low fertility.

However, the absence of corrections and fertilization of the soil cannot be justified in pastures; these management practices are necessary because soil fertility greatly limits the crops' ability to achieve maximum productivity.

To use wood ash as a fertilizer, certain criteria must be met, such as attaining knowledge in the area of soil science, especially in relation to its effects on soils of different classes. The application of wood ash can reduce the use of mineral fertilizers and, consequently, production costs, and it promotes the safe disposal of wood ash in the environment (Bonfim-Silva et al., 2014). Thus, considering the beneficial use of wood ash as a soil fertilizer, this study aimed to evaluate the productive characteristics of Marandu grass cultivated in two classes of Cerrado soils when fertilized with wood ash.

MATERIALS AND METHODS

The experiment was conducted in a greenhouse during the period from December, 2012 to May, 2013 in Rondonópolis City, Mato Grosso States (MT), Brazil. The forage grass *Brachiaria Brizantha* was used as the Marandu grass grown in pots with a capacity of 5 dm^3 of soil. The experimental design was completely randomized in a 2 × 6 factorial design, with two Cerrado soils (oxisol and ultisol) and six doses of wood ash (0, 3, 6, 9, 12 and 15 g dm^{-3}) in six replicates. The two soils were collected at the 0 to 20 m layer in an area under Cerrado vegetation in the region of Rondonópolis City, and chemical and textural characterizations were performed according to EMBRAPA (1997).

The oxisol had the following chemical and textural characteristics: pH in $CaCl_2$ = 4.1; M.O. = 19.7 g dm^{-3}; P = 1.1 mg dm^{-3}; K = 47.0 mg dm^{-3}; Ca = 0.2 cmolc dm^{-3}; Mg = 0.1 cmolc dm^{-3}; Al = 1.0 cmolc dm^{-3}; H = 4.7 cmolc dm^{-3}; CTC = 6.1 cmolc dm^{-3}; V = 6.9% m = 70.4%. In addition, the oxisol had the following physical characteristics: sand = 575 g kg^{-1}; clay = 375 g kg^{-1} and silt = 50 g kg^{-1}.

However, the ultisol presented the following chemical and textural characteristics: pH in $CaCl_2$ = 4.9; M.O. = 6.2 g dm^{-3}; P = 4.8 mg dm^{-3}; K = 25.0 mg dm^{-3}; Ca = 1.0 cmolc dm^{-3}; Mg = 0.6 cmolc dm^{-3}; Al = 0.1 cmolc dm^{-3}; H = 1.5 cmolc dm^{-3}; CTC = 3.3 cmolc dm^{-3}; V = 50.9% and m = 5.7%. In addition, the ultisol had the following physical characteristics: sand = 830 g kg^{-1}; clay = 120 g kg^{-1} and silt = 50 g kg^{-1}.

The wood ash used in this study was derived from the region Rondonópolis, MT ceramic industry, and it is characterized as fertilizer (Darolt et al., 1993) with the following chemical characteristics: pH in $CaCl_2$ = 7.85; N = 0.17%; P_2O_5 (neutral ammonium citrate + water) = 1.42%; K_2O = 0,32%; Zn = 0.00%; Cu = 0.01%; Mn (CNA + water) = 0.00; Ca = 0.90% and S = 1.60%.

Both soils were incubated with wood ash for a period of 30 days. The powdered wood ash had soil amendments; thus, the soils did not have to be limed.

After the incubation period, 15 seeds of Marandu grass were sown, and after the plants reached an average height of 10 cm (which occurred at 12 days after sowing), the plants were thinned to five plants per pots and treated with nitrogen fertilization. Plants were fertilized after thinning and after each cut was performed with nitrogen (source: urea) at 200 mg dm^{-3}. Nitrogen fertilization was performed in all of the experimental units, and soil moisture was maintained at 80% of the gravimetric maximum water retention in the soil during the driving period of the experiment.

The interval between the Marandu grass cuts (three total) was 30 days, and after each cut, an assessment was made of the dry mass of shoots and roots (only on the third cut), number of leaves and number of tillers. The plant material was collected at each cut, dried in an oven with forced air circulation at 65 for 72°C h until a constant weight, and after drying, it was weighed on a balance scale to determine the mass.

Data were subjected to an analysis of variance by F-test, and for significant results, the qualitative factors for soil type were submitted to Tukey's test and quantitative factors for the dose of wood ash were submitted to a regression analysis, both at a 5% probability using the statistical program Sisvar (Ferreira, 2008).

RESULTS AND DISCUSSION

The application of wood ash as a fertilizer to the two classes of soils provided increments of productive characteristics of the Marandu grass with and interaction effects at the first and second cuts of the forage grass. At the third cut, there was an isolated effect, with an increased dry mass of shoots observed in the ultisol (Table 1).

In the first cut of the forage grass, the dry mass of the shoots was adjusted by a linear regression model for ultisol and oxisol, and an increase was found of 81.49 and 69.43%, respectively, when comparing the highest dose of wood ash (15 g dm^{-3}) to the treatment without fertilization with wood ash (Figure 1A).

In the second cut of the Marandu grass, there was interaction between the doses of wood ash and soil types in the dry mass of shoots. The oxisol was adjusted by a linear regression model, and an increase was found of 21.61% when the higher dose of wood ash (15 g dm^{-3}) was compared to the treatment without fertilization with wood ash. The forage grass grown in ultisol had a minimal production of dry mass of shoots in the wood ash dose of 7.06 g dm^{-3} (Figure 1B).

In the third evaluation, there were no significant differences in dry mass of the aerial parts of the Marandu grass grown ultisol. For the oxisol, the dry mass of the shoots was fit with a quadratic regression model, and the mass production of shoots was 6.15 g pot^{-1} at a wood ash dose of 11.80 g dm^{-3} (Figure 1C).

In both soils, there was a differential effect of wood ash in the production of dry mass, so at the first cut of the

Table 1. Isolated effect of soil on the dry mass of shoots (DMS) the of Marandu grass, the third cut fertilized with vegetable ash (g DMS g cinza^{-1}).

Soils	Dry mass of shoots
Oxisol	5.10^{b}
Ultisol	6.22^{a}
CV%	25.29

Means followed by the same letter in the line do not differ by Tukey's test at a 5% probability. CV% = Coefficient of variation.

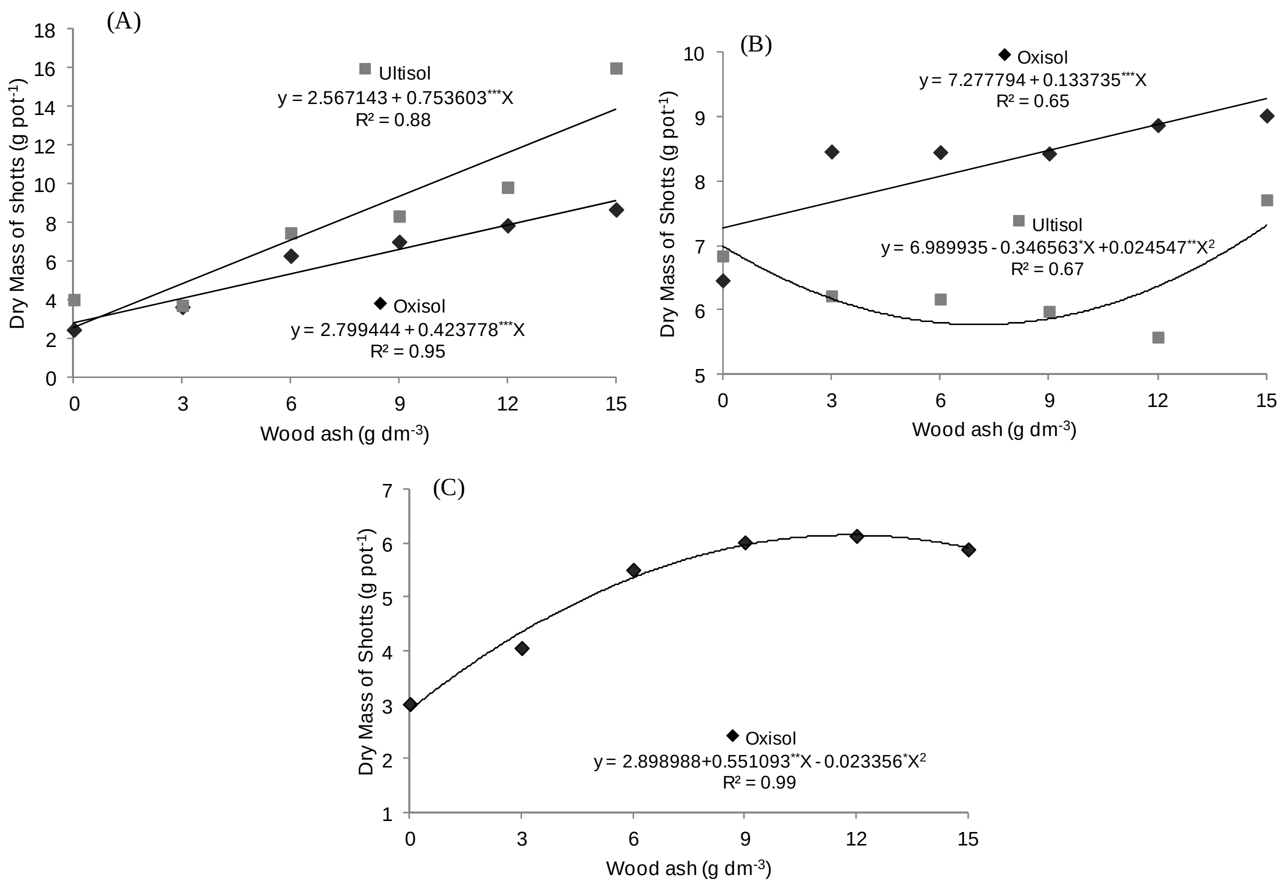

Figure 1. Dry mass of shott of Marandu grass subjected to doses of wood ash in oxisol and ultisol soil: the first (A) and second (B) cuts, and Oxisol in the third cut (C). *, ** and *** represent 5, 1 and 0.1% probability, respectively.

grass, the linear fit of this variable revealed that even when grown in different soils, the forage grass was not distinguished in its responses to fertilization with wood ash. The fit by the linear regression model can be justified by the need to prioritize the forage grass root development in the establishment phase, which allocated the forage grass assimilates to the roots of plants.

However, at the second cut, the fit to a quadratic regression model of the dry mass of shotts of the forage grass that was observed in ultisol may have shown an effect of the wood ash in the availability of nutrients in the soil, which would reflect the inherent characteristics of each soil in the ability to react with this residue. It is noteworthy that the oxisol soil showed an increased fertility during the characterization.

In the third section, the quadratic fit of the mass of shoots of the Marandu grass grown in oxisol may have been related to the residual effect of fertilization by the wood ash because there was no reapplication of this residue in the treatments. Thus, the mass production of

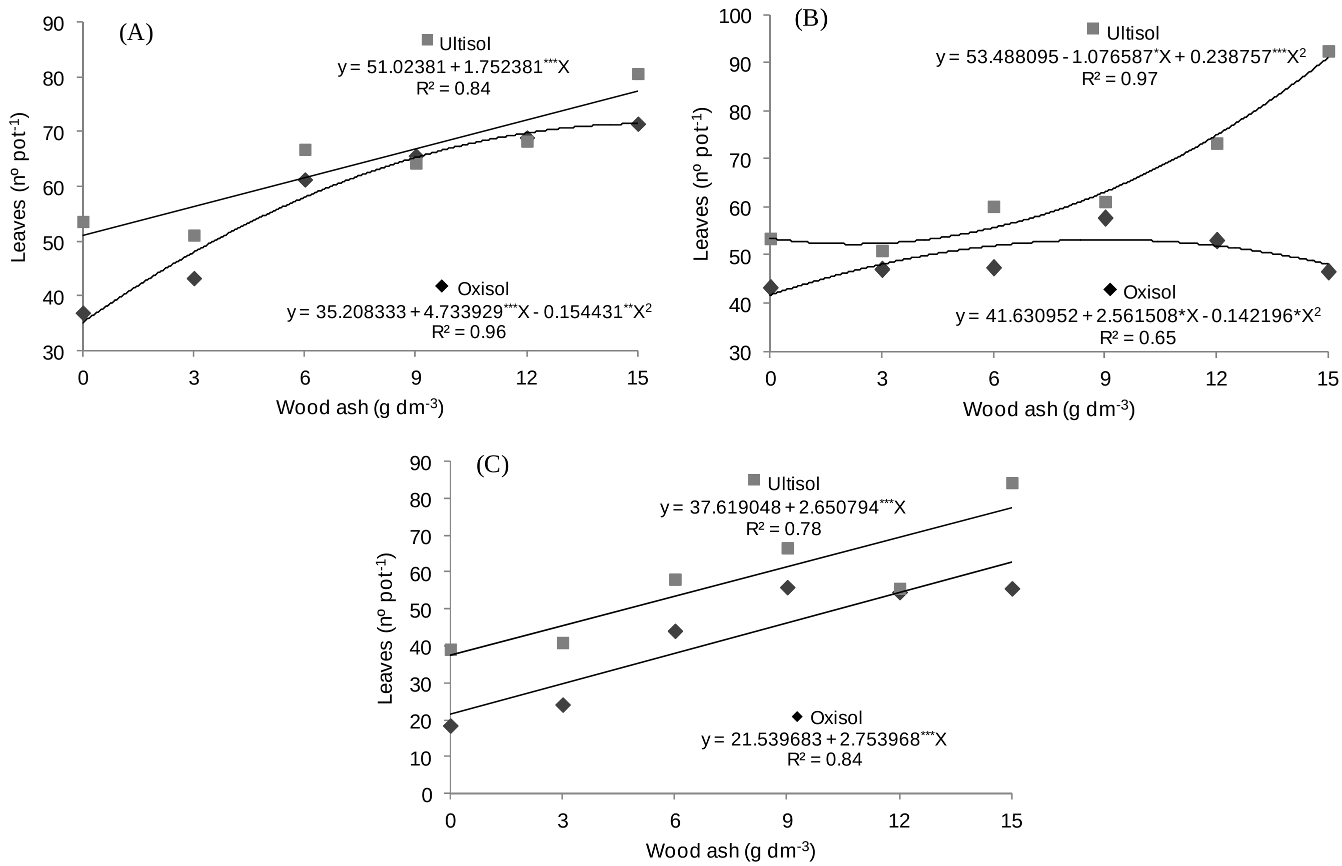

Figure 2. Number leaves in Marandu grass subjected to doses of wood ash in Oxisol and Ultisol soils at the first (A), second (B) and third (C) cuts. *, ** and *** represent 5, 1 and 0.1% probability, respectively.

shoots in the Marandu grass ultisol was not significant, which indicates that mass production likely tended to stabilize, so no significant differences were found.

Research conducted with the wood ash in the Cerrado oxisol soil showed that Marandu grass did not reach the maximum mass production of its shoot because of the low presence of minerals in the chemical composition of the ash wood (Bonfim-Silva et al., 2013). The mineral nutrients present in the plant ash directly influenced the production of the plant.

Santos (2012) studied the Marandu grass fertilization with wood ash in Cerrado oxisol and set the observed quadratic regression model according to the dry mass of the shoots fertilized with wood ash, which emphasized that the wood ash had concentrations of nutrients that could satisfy the nutritional demand of the crop.

In the present study, the Marandu grass grown in ultisol produced 13.87 g pot^{-1} of shoot mass, which was consistent with the results of Abreu and Monteiro (1999), Maciel et al. (2007) and Cabral (2011), who used mineral fertilizers; however, it is evident that the use of wood ash as a soil fertilizer improves soil fertility by increasing the production of this forage grass.

At the first cut, leaf production was adjusted to a quadratic regression model for the Marandu grass grown in field experiments, and the highest number of leaves (71.49) occurred at a wood ash dose of 15.33 g dm^{-3}. However, when the Marandu grass was grown on ultisol, the number of leaves was adjusted to a linear regression model and showed an increase of 34.0% in the number of leaves when the dose at 15 g dm^{-3} was compared to a treatment without fertilization with wood ash (Figure 2A).

The number of leaves of forage grass at the second cut was fit to a quadratic regression model, and the largest number of leaves of grass grown in the field experiment was 53.16 leaves in the wood ash treatment with a dose of 9 g dm^{-3}. The lowest number of leaves (52.27) of Marandu grass grown in ultisol was obtained at a wood ash dose of 2.25 g dm^{-3} (Figure 2B).

The production of Marandu grass leaves at the third cut was adjusted by a linear regression model for the oxisol and ultisol soils, and it showed an increment of 65.73 and 51.38%, respectively, at the highest dose of wood ash compared to the treatment without fertilization by wood ash (Figure 2C).

This study confirms the results by Bonfim-Silva et al. (2011), who applied doses of wood ash to Marandu grass in oxisol and observed an increase in the number of

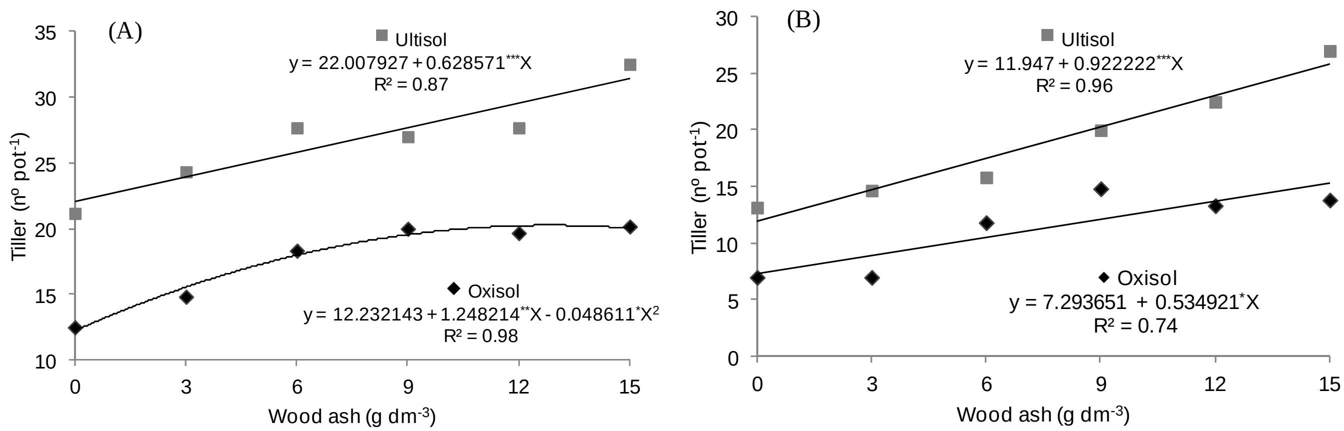

Figure 3. Tiller number in Marandu grass subjected to doses of wood ash in Oxisol and Ultisol soil at the second (A) and third (B) cuts. *, ** and *** represent 5, 1 and 0.1% probability, respectively.

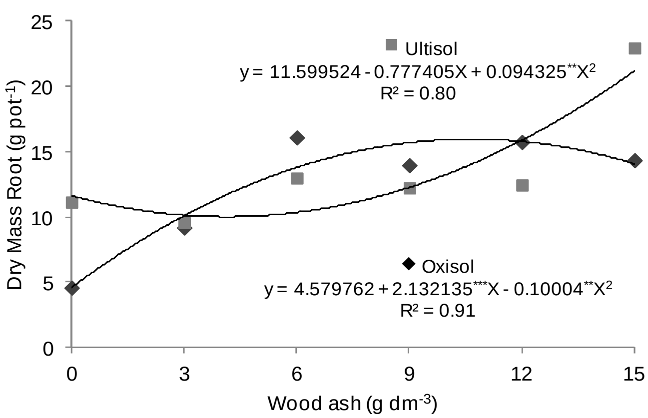

Figure 4. Dry mass root of Marandu grass subjected to doses of wood ash in oxisol and ultisol soils. ** and *** represent 1 and 0.1% probability, respectively.

leaves at the first and second cuts. Similarly, Santos (2012) studied the effect of wood ash in two cultivars of *B. brizantha* and noted that the production of Marandu grass leaves was positively influenced, which confirms the importance of using this waste as a fertilizer.

For the production of tillers, there was no significant effect at the first cut of Marandu grass. At the second cut, the maximum production of tillers set by the quadratic regression model when grown on oxisol was 20.24 tillers at a dose of 12.84 g dm^{-3} wood ash. Ultisol was adjusted by a linear regression model, and there was an increase of 29.99 and 53.66% at the first and second cuts, respective, when the highest dose of wood ash was compared to the treatment without wood ash (Figure 3A and B).

It was observed that at the second cut of the Marandu grass, the highest dose of wood ash applied to the ultisol soil was similar to the production at an equivalent amount of mineral fertilizer (nitrogen and sulfur) in the tiller of Marandu grass studied by Batista and Monteiro (2006). Thus, we emphasize the potential use of wood ash fertilization on forage grass.

Bonfim-Silva et al. (2011) observed linear effects in the number of tillers of the first two Marandu grass intervals, which had 2.5 to 2.0-fold increases, respectively, at higher doses of wood ash (3.37 g dm^{-3} reapplied every cut forage) compared to the control. According to Santos (2012), the use of wood ash as a fertilizer was also shown to produce significant number of tillers of Marandu grass in Cerrado oxisol soil.

The dry mass root of Marandu grass was set by the quadratic regression model at the minimal production amount observed in the wood ash treatment at a dose of 4.12 g dm^{-3} in ultisol. Moreover, we observed a higher production of 15.94 g pot^{-1} at a wood ash dose of 10.65 g dm^{-3} when the grass was grown in oxisol (Figure 4).

When the Marandu grass is grown on typic oxisol, it produces a higher root dry mass than when grown in ultisol. Considering that the soil fertility of the oxisol had a higher nutrient limitation, the nutrients provided through the application of wood ash improved the relative proportion of these nutrients in the soil, which was shown by the maximum root production, demonstrating the importance of using this residue, especially in soils of low fertility.

Bonfim-Silva et al. (2013) observed a maximum production of roots in Marandu grass at 21.03 g pot^{-1} in the oxisol fertilized with a wood ash dose of 3.29 g dm^{-3}. It is noteworthy that these authors reapplied doses of wood ash to the surface after the first cut. Santos (2012) observed that the production of this grass root was 60.96 g pot^{-1} at a wood ash dose of 15 g dm^{-3}.

The application of the wood ash residue thus increases the production potential of oxisols because the wood ash promotes the rapid release of nutrients and there is a subsequent increase in soil fertility (Guariz et al., 2009).

Conclusions

Wood ash as a fertilizer influences the productive characteristics of Marandu grass in Cerrado soils. In the oxisol soils, Marandu grass presents its maximum production of the dry mass of shoots, number of leaves, number of tillers and root mass in doses of wood ash of 11.80, 9.0, 12.84 and 10.65 g dm^{-3}, respectively.

In ultisol, a linear fit and minimal production were observed for the productive characteristics of Marandu grass; however, the dry mass of the shoots did not differ between the two soil types.

Conflict of Interest

The authors have not declared any conflict of interest.

ACKNOWLEDGEMENTS

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REFERENCES

Augusto L, Bakker MR, Meredieu C (2008). Wood ash applications to temperate forest ecosystems: Potential benefits and drawbacks. Plant Soil 306(1-2):181-198. http://dx.doi.org/10.1007/s11104-008-9570-z

Batista K, Monteiro FA (2006). Respostas morfológicas e produtivas do capim-marandu adubado com doses combinadas de nitrogênio e enxofre. Rev. Bras. de Zootec. 35(4):1281-1288. http://dx.doi.org/10.1590/S1516-35982006000500005

Bonfim-Silva EM, Cabral CEA, Silva TJA, Moreira JCF, Carvalho JCS (2013). Cinza vegetal: características produtivas e índice de clorofila do capim-marandu. Biosci. J. 29(5):1215-1225.

Bonfim-Silva EM, Santos CC, Silva TJA. Scaramuzza WLMP (2014). Concentration of nitrogen, phosphorus and potassium in tropical grasses fertilised with wood ash in Cerrado oxisol. Afr. J. Agric. Res. 9(5):549-555. http://dx.doi.org/10.5897/AJAR2013.8278

Bonfim-Silva EM, Silva TJA, Cabral CEA, Valadares EM, Goldoni G (2011). Características morfológicas e estruturais de capim-marandu adubado com cinza vegetal em Latossolo Vermelho do Cerrado. Enciclopédia Biosfera, Centro Cientifico Conhecer 7(2):1-9.

Cabral CEA (2011). Capins marandu, decumbens e convert submetidos à adubação nitrogenada. 90 f. Dissertação (Mestrado em Agricultura Tropical) -Faculdade de Agronomia e Medicina Veterinária, Universidade Federal de Mato Grosso, Cuiabá, Brasil.

Cabral F, Ribeiro HM, Hilário L, Machado L, Vasconcelos E (2008). Use of pulp mill inorganic wastes as alternative liming materials. Bioresour. Technol. 99(17):8294-8398. http://dx.doi.org/10.1016/j.biortech.2008.03.001

Coelho P, Costa M (2012). Combustão. 2.ed. Amadora: Edições Orion, P. 714.

Darolt MR, Blanco Neto V, Zambon FRA (1993). Cinza vegetal como fonte de nutrientes e corretivo de solo na cultura de alface. Hort. Bras. 11(1):38-40.

Embrapa (1997). Empresa Brasileira de Pesquisa Agropecuária. Manual de métodos de análises de solo. Centro Nacional de Levantamento e Conservação do Solo. Embrapa Solos. P. 212.

Ferreira DF (2008). SISVAR: um programa para análises estatísticas e ensino de estatística. Rev. Symposium 6:36-41.

Ferreira EPB, Fageria NK, Didonet AD (2012). Chemical properties of an Oxisol under organic management as influenced by application of sugarcane bagasse ash. Rev. Ciênc. Agron. 43(2):228-236. http://dx.doi.org/10.1590/S1806-66902012000200004

Guariz HR, Picoli MHS, Campanharo WA, Rodrigues BP (2009). Uso de cinzas de fornos de cerâmica como fonte de nutrientes para aproveitamento na agricultura. In: Congresso Brasileiro de Resíduos Orgânicos. Anais. Vitória, Brasil.

Lima RLS, Severino LS, Beltrão NEM, Ferreira GB (2006). Efeito da adição de cinza de madeira e esterco bovino no crescimento inicial da mamoneira cultivada em solo ácido. In: Congresso Brasileiro de Mamona, 2, Aracaju. Anais. Aracaju. Embrapa, CNPA.

Lima RLS, Severino LS, Albuquerque RC, Ferreira GB, Sampaio LR, Beltrão NEM (2009). Capacidade da cinza de madeira e do esterco bovino para neutralizar o alumínio trocável e promover o crescimento da mamoneira. Rev. Brasileira de Oleaginosas e Fibrosas 13(1):9-17.

Loué A (1978). Potassium Research. Research and Trends. Eern, International Potash Institute, pp. 407-433.

Maciel GA, Costa SEGVA, Furtini Neto AE, Ferreira MM, Evangelista AR (2007). Efeito de diferentes fontes de fósforo na Brachiaria brizantha cv. capim-Marandu cultivada em dois tipos de solos. Ciênc. Anim. Bras. 8(2):227-233.

Nieminen M, Piirainen S, Moilanen M (2005). Release of mineral nutrients and heavy metals from wood and peat ash fertilizers: Field studies in Finnish forest soils. J. Forest. Res. 20:146-153.

Nkana JCV, Demeyer A, Verloo MG (2002). Effect of wood ash application on soil solution chemistry of tropical acid soils: incubation study. Biores. Technol. 85(3):323-325. http://dx.doi.org/10.1016/S0960-8524(02)00140-2

Obernberger I, Biedermann F, Widmann W, Riedi R (1997). Concentrations of inorganic elements in biomass fuels and recovery in the different ash fractions. Biomass. Bioener. 12(3):211-224. http://dx.doi.org/10.1016/S0961-9534(96)00051-7

Osaki F, Darolt MR (1991). Estudo da qualidade de cinzas vegetais para uso como adubos na região metropolitana de Curitiba. Rev. Setor Ciênc. Agrar. 11(1):197-205.

Pita, PVV (2009). Valorização agrícola de cinza da co-combustão de bagaço de cana-de-açúcar e biomassa lenhosa. 120f. Dissertação (Mestrado em Engenharia Agronômica) – Instituto Superior de Agronomia, Universidade Técnica de Lisboa, Lisboa, Portugal.

Santos, CC (2012). Cinza vegetal como corretivo e fertilizante para os capins Marandu e Xaraés. 127f. Dissertação (Mestrado em Engenharia Agrícola) – Instituto de Ciências Agrárias e Tecnológicas, Universidade Federal de Mato Grosso, Rondonópolis, Brasil.

Sofiatti V, Lima RLS, Goldfarb M, Beltrão NEM (2007). Cinza de madeira e lodo de esgoto como fonte de nutrientes para o crescimento do algodoeiro. Rev. Biol. e Cien. Terra 7(1):144-152.

Zimmerman S, Frey B (2002). Soil respiration and microbial properties in an acid forest soil: effects of wood ash. Soil Biol. Biochem. 34(11):1727-1737. http://dx.doi.org/10.1016/S0038-0717(02)00160-8